land were ploughed up, and as the ice moved forward over the irregular surface, it became more or less filled with boulders, gravel and sand, at least to the height of the peaks and ridges which it crossed. Differences in the slope of the surface of ice above, like those which made an angle in the terminal moraine, due apparently to inequalities in the amount of snowfall and of melting upon adjacent regions, must also produce downward and upward currents by which these materials would be distributed throughout the lower part of the ice, probably to the height of several hundred feet, even while crossing a nearly level area.

By the melting of the ice-sheet at and near its terminal front, this detritus was exposed, through every summer, to the washing of many rills and small streams; but before its retreat under a change of climate, this melting was extended over a very wide area. The surface of the ice was then hollowed into basins of drainage and channelled by rivers, which became heavily freighted with the gravel, sand and clay that had been held in its mass. A large portion of this gravel and sand was heaped at the edge of the ice-sheet, where these glacial rivers descended to the lower open area beyond. When the ice behind them disappeared these deposits were left in the massive hills and ridges of stratified drift which form so prominent a part of these series of terminal moraines. [*To be Continued.*]

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THE GEOLOGICAL MUSEUM OF THE SCHOOL OF MINES, COLUMBIA COLLEGE.

BY ISRAEL C. RUSSELL.

AS it is impossible for every one to visit distant lands, or even at all seasons to go forth into the fields and among the mountains in quest of geological knowledge, we desire to call the attention of our readers to a collection in our country which in a great measure will supply these wants. We refer to the Geological Museum under the direction of Prof. J. S. Newberry, at the School of Mines, Columbia College, New York city. Here the visitor will find a most interesting display of the remains of the ancient inhabitants of the globe, gathered not only from the rocks of our own country, but also from the most distant lands, and each arranged in its proper place in the long series.

The geological museum occupies the entire third story of the

eastern wing of the School of Mines building, and consists of four collections, all of which, however, have an intimate connection with each other. The first and most interesting of these is the geological and palæontological collection, which will be the subject of our present sketch. This is supplemented (firstly) by a lithological collection consisting of three thousand specimens of rocks and the minerals which compose rocks; (secondly) by a collection in economic geology, containing nine thousand specimens of coal, ores, marbles, fertilizers, etc., illustrating the mineral wealth of our country, and containing also suites of ores and associated rocks from many of the most important mines in foreign lands; (thirdly) as an aid to the study of the fossil remains of animals and plants, which constitute the most attractive branch of geological knowledge, a zoölogical and botanical collection has been added, composed of well-selected specimens which in some peculiar manner serve to explain the fossil forms. This collection in some departments, as in that of fishes, contains many remarkable and interesting and valuable specimens.

The portion of the museum to which we wish to introduce the reader is the first we have mentioned, that of geology and palæontology. This collection occupies the wall and table cases on the eastern side of the hall; many large specimens, however, as the skeleton of the Irish elk, a cast of the Megatherium, etc., are arranged in various parts of the museum.

The cases, commencing at the northern end of the hall and extending throughout its entire length, present the geological records from the earliest dawn of life on our planet down to the last chapter in its history—the introduction of man.

These sibyl's pages, gathered from the ends of the earth, present an epitome of the world's ancient history written by the unprejudiced hand of nature. These fragments of stone with the curious forms of animals and plants engraved upon them, are to the geologist—the interpreter of the earth's history—what the hieroglyphics of Egypt or the picture-writings of Mexico are to the archæologist—the translator of human history.

Before we enter into an examination of the remains of animals and plants which once lived upon the earth, but are now extinct, we should clearly understand that fossils are the records which these ancient organisms have left of their existence. In some instances, as with the Irish elk and the moa of New Zealand,

we find the bones themselves but little altered from their original condition. At other times the organic matter of the specimen, a piece of wood, a bone, a shell it may be, have been replaced by silica so as not only to retain the general form, but even the most minute structure of the original substance. Such a replacement is called petrifaction. Wood is frequently thus petrified so as to preserve its microscopical structure as perfect as it was when the plant was yet in leaf. Again we may find but the impression of a fern or of a fish, made in soft mud or sand, which has been hardened into rock and has faithfully preserved the form of the frail body that perished ages ago. The plastic mud along the shores of bays and rivers is frequently trodden by animals or pitted by falling rain-drops; such a surface by becoming covered by a layer of sand or mud may retain for indefinite ages the inscriptions thus impressed upon it. In these and many other ways, the life-history of distant ages has been written on the rocks and preserved to our own day, with an accuracy and fidelity which cannot be too highly appreciated.

The great interest connected with the first appearance of life on the globe is indicated by the prolonged discussion that took place in reference to the organic nature of the eozoön, which, as far as at present known, is truly the "dawn animal" of the world. Specimens of this interesting fossil are contained in the first case at the northern end of the geological hall. Now that we have made the first step in our journey through the geological ages as here arranged, we will pass slowly down the long row of cases, and in doing so, review hastily the life-history of the earth.

The Eozoön belongs to the lowest sub-kingdom of animal life, the *Protozoa*, which also embraces our familiar sponges, the structureless amœba, etc. The case containing the Eozoön shows us also the forms of life that followed this humble beginning. These are the fossils of the Silurian age, or the age of mollusks, as it is sometimes called in reference to the great abundance of the remains of "shell-fish," which far outnumber all the other fossils of this formation. The collection contains six thousand specimens of this ancient fauna, which were all embraced in the first four sub-kingdoms of animal life. The *Protozoa* are represented by the Eozoön, sponges, receptaculites, etc.:—the Radiates by corals, crinoids, and star-fishes. The Mollusks, as we have mentioned, were in great force, as the fossil shells testify. The

numerous trilobites, with the Eurypterus, Pterygotus, etc., show us that the Crustaceans were the highest form of life on our continent during the Silurian age. But while the Crustaceans were the highest in point of structure, yet they were far inferior in size and strength to the Cephalopods, the highest of the Mollusks, which lived in the same seas. These were represented by huge Orthoceratites. As we stand beside the cases containing these beautifully preserved remains, it is not difficult to restore them once more in fancy to the ancient waters in which they lived, and to picture to ourselves the appearance of the earth in that distant age. All the remains of animal life which these cases contain are those of marine forms. All the remains of plants, too, discovered in the rocks of this age have been classed with the Algæ (or sea-weeds). Judging from the fossil records, which, however, we feel are incomplete, we conclude that no plants grew upon the Silurian land areas.[1] There was then but the broad ocean and the wild desolate shores, uninhabited by beast, or bird, or plant—even more dreary and silent than are now the barrenest islands of the southern oceans. Along these primeval shores the waves rolled in and ground away the rocks as they do on the coast to-day, and retreating left the sands with a ripple-marked surface or covered with the trails of worms and crustaceans. Many of the shell-fish and trilobites lived along the shore, perhaps sheltered by clumps of sea-weed and clinging brachiopods, others inhabited deeper waters and contributed their remains to the formation of the limestone in which we now find them.

With this imperfect glimpse of our country in the Silurian times, we must pass on to the fauna and flora of the next succeeding, Devonian, age. Again naming the era from the ruling forms of life, we call this the age of fishes. Although in Europe the first fishes made their appearance in the preceding age, yet in our country we find their earliest remains in the Devonian rocks, throughout which time they continued to be the highest forms of life on the globe. What at once strikes the observer upon glancing over the splendid display of Devonian fossils here brought together, is the almost total absence of the forms with which we have already become familiar in the Silurian. Here begins a new chapter in the ancient archives. The few inches

[1] Since this was written a number of species of land plants have been described from the Silurian rocks of our country by Mr. Leo Lesquereux.

that separate the Silurian from the Devonian fossils represent in reality an immense lapse of time, during which the fauna of the world underwent great changes. We will not say that all the old forms of life were exterminated and new beings created to take their places, nor can we prove that during these unknown ages the laws of development were slowly changing the plastic organisms into new forms better adapted to meet the altered conditions under which they were forced to live. We can only say that the record is broken: to-morrow the missing chapters may be discovered and new light thrown upon the enigma, but to-day we must pass it by. But while most of the fossils of the Devonian differ in genera and species from those of the older fauna, yet they belong to the same families and orders, with the exception, of course, of the fishes, which are new to the life of the world. The corals, mollusks, and crustaceans are present in great numbers, and in a general way resemble their representatives in the Silurian, but on the whole they present greater diversity and indicate more advanced conditions. The presence of corals in the rocks of this age in what are now the Arctic regions indicates that there was little diversity of climate at the time these animals were alive.

The fossils which particularly attract the attention in these cases, and which will always be a center of interest to the student of the Devonian, are the remains of fishes, of which this collection contains a grand display that is unrivaled by any other museum in this country. Many of these fossils are unique, and in some instances are the only specimens of their kind known; many of them being the types figured by Prof. Newberry in the Geological Reports of Ohio. Among the first objects to attract the attention are the great sword-shaped spines which are the type-specimens of the genus *Machæracanthus*; these highly-polished spines, some of which are twenty inches in length, are samples of the weapons worn by the old Devonian sharks. These ancient fish-spines illustrate the economy that is shown in so many of nature's works, in gaining great strength with the use of the smallest possible amount of material. Here also are the type-specimens of the genera *Acanthaspis* and *Acantholepis*, which show a strange combination of plate and spine that is unknown in modern fishes. Another slab of limestone shows the head of an old Devonian fish that measures seven or eight inches in length. The head of this fish was completely encased with solid bony plates that

were strongly united by sutures and highly ornamented on the exposed surfaces. This fish, which has received the long name of *Macropetalichthys*, seems to have had many features in common with the structure of the living sturgeon. One of the strangest fishes that ever swam in the Devonian seas, and which surpasses in interest even the *Pterichthys* and *Coccosteus* of the old world, is the *Onychodus*. Among the most unique specimens in the museum is a slab of limestone from the Corniferous rocks of Ohio, containing a nearly perfect mandible of this fish, which is fourteen inches in length and set with sharp conical teeth. At the junction of the two rami of the lower jaw, there occurs a crest of seven large curved teeth which seem to have projected beyond the massive jaws, thus forming a terrible weapon, whose use seems to have been analogous to that of the sword in the living sword-fish. Far more wonderful than any of these, and one of the strangest monsters ever exhumed from the cemeteries of the primeval world, is the *Dinichthys*, described by Prof. Newberry from the Huron shales of Ohio. The nearly perfect bony casing of this "terrible fish," which is exhibited, shows it to have been upwards of twenty feet in length; and judging from its formidable armament, it was by far the most destructive creature yet known from the Devonian rocks. The jaws are massive plates of dense bone, each two feet in length, and provided with sharp-cutting and serrated edges. The anterior ends of the mandibles are upturned and united so as to form one immense tusk-like tooth, which shuts in between two equally massive premaxillaries on the upper jaw. The jaws of *Dinichthys* may be well represented by the arms of a man extended to their full length with the hands turned up and pressed together to represent the great tooth at the junction of the mandibles. One of the most curious and interesting features connected with this discovery is the striking analogy that exists between the structure of the *Dinichthys* and the mud-fish (*Lepidosiren*) now living in the rivers of Africa and South America. The number of these Devonian fishes is so great that we can but glance at a few of the more interesting ones that remain. Beside the dorsal shield of *Coccosteus* from the Old Red Sandstone of Scotland, is placed the only similar specimen known of *Coccosteus* from this country. Here too is the type-specimen of the genus *Heliodus*, one of the most ancient of the Dipnoi. Specimens of *Rhynchodus* show us that the modern Chimæra belongs to a very ancient family.

We cannot linger over these ancient relics, which are but waiting the pen of a Hugh Miller to make them familiar to every reader in our land, but must pass on to other features of the Devonian, which are well exhibited in these cases. Our readers will remember that the shores of the Silurian ocean were barren solitudes. Not so was it in the Devonian. We have here before us the remains of a strange and luxuriant flora that shaded the land. Ferns grew luxuriantly; above these flourished the strange *Lepidodendrons*, with which we shall become more familiar in the age that follows. We have here the first appearance of the most beautiful of land-plants, the tree-ferns, which at the present day form such an attractive feature in the scenery of the tropics and of the islands of the South Pacific.

The next series of cases contains the remains of the fauna and flora that flourished in the Carboniferous times—the age which witnessed the formation of the great coal-fields of America. Here the scene again changes. The mollusks and crustaceans, the huge ganoids and the strange flora, of the Devonian age, have disappeared never to return again. Another cycle in the world's history has been completed. The fossils which we have now to examine are, as before, the remains of shells, fishes, plants, etc., but all very different from those of the Devonian. Fishes appear again in great numbers, but not the huge Placoganoids that we saw before, but the elegantly-formed Lepidoganoids, covered with little plates of enameled bone. The most beautiful of these fossil fishes are from the cannel coal deposits of Linton, Ohio. The fossilization in these specimens is peculiar. Each little plate of mail and each delicately-penciled fin seem wrought in gold-leaf on a black ground. In reality, the substance which represents the fish is iron-pyrites, on a surface of impure coal. These little fishes have received the generic title of *Eurylepis*, in reference to the breadth of their scales, and such specific names as *corrugata*, *insculpta*, *lineata*, *ornatissima*, etc., suggested by their delicate ornamentation. Specimens of *Cœlacanthus*, which occur with the *Eurylepis*, are even more highly ornamented, and have their scales and head-plates so elegantly chased that the most skillful gem-engraver could scarcely imitate their delicate tracery. The great fin-spines which these cases contain, show that the sharks were strongly represented in the Carboniferous waters. Here too are the teeth of the most gigantic ray ever discovered (*Archæobatis*),

some of the flat crushing teeth of which were six inches in length, four inches wide, and an inch and a half thick.

Some of the slabs of stone from Linton, Ohio, upon being split open, showed the heads, limbs, scales, etc., of *Amphibians*, represented at the present time by the frogs and salamanders. It is at once apparent that this is the heading of a new chapter. In all the stony pages that we have glanced over, we have not seen characters like these. If we should follow out the records here begun, through all the following ages, we would find, indeed, that it is a chapter of wonders, containing the lives and struggles of the hugest and strangest monsters that have ever lived. We cannot pass on, however, without glancing at the flora of the Carboniferous, the relics of which these cases contain to overflowing. These forms, that are traced so delicately on the stones, were once living plants that millions of years ago bowed to the passing winds and drank in the sunshine as our most familiar trees and ferns do to-day. These fragments of trunks, branches, leaves and cones give us a faint glimpse into the dark moist forests that clothed our land in the coal period. Many of the fossil plants we at once recognize as ferns, so nearly do they approach in form these beautiful plants which we meet in all our rambles. Others, after considerable study, have been shown to be closely related to the little ground-pines or club mosses, which are also quite common in our woods. These ancient Lycopods, however, instead of being only a few inches in height, with cones an inch long, were gigantic trees sometimes upwards of seventy or eighty feet in length, with elegantly scarred trunks, and bearing large cones upon their gracefully pendant boughs. Another of our common plants, the Equisetum, also had giant representatives in that ancient flora. These, together with the Sigillarias, with their beautifully fluted columnar trunks, furnished the material from which our great stores of coal were formed. What at once appears as a remarkable fact upon looking over these fossils, is that they all belong to the lowest grade of vegetation, the cryptogamous or flowerless plants. Among all the hundreds of coal plants here assembled, we look in vain for so much as a single leaf of a broad-leaved plant like our maples and oaks. It was long supposed that there was a total lack of flowers in the Carboniferous forests, but a specimen in this collection shows a branch of some unknown plant with the remains of flowers clearly distinguishable.

As we pass on to the records of the next succeeding (Mesozoic) eras, the mediæval age of geology, we find no mention made of the luxuriant forests and the abundant animal life that passed before. Nearly all remembrance of these seems lost in antiquity. This age, in reference to the predominating forms of life, is called the reptilian age. The first indications that we have of these new rulers of the land and sea, are their foot-prints, left along the muddy shores. Some of these from New Jersey and the Connecticut valley are shown in the case of Triassic fossils. These wonderful impressions are so well known through the writings of Prof. Hitchcock and others, that we need do no more than mention them. The rocks in which these foot-prints were found have also furnished great numbers of fossil fishes. Among hundreds of specimens of these Triassic fishes here assembled, there is one called *Ptycholepis*, with highly ornamented head-plates and plicated scales, which is the only American specimen known of this genus, which occurs in the Lias of Europe; here too is the only specimen yet discovered of *Diplurus*; this was lately obtained from the Triassic rocks at Boonton, N. J. The rocks of this age have also yielded the oldest remains known of the Mammalia. This sub-kingdom makes its appearance in one of its humblest orders, the Marsupials, represented at the present day by the opossum and the kangaroo.

In the flora of the earlier portion of this age we find ferns, calamites, and conifers, with the addition of a new feature, the Cycads. As we pass on to the cases containing the fossil plants from the latest period of this age, the Cretaceous, we come suddenly to a splendid display of fossil leaves which have a wonderfully familiar appearance; they are the leaves of oaks, willows, maples, beeches, sycamores, etc., which the most casual observer would refer to the same genera that are living at the present day. There are differences which show that all these fossil leaves are specifically distinct from their modern representatives.

Among the most striking forms of animal life in the Mesozoic, were the Cephalopod shells, related to the living Nautilus. Of these, the ammonites which were foreshadowed by goniatites in the Devonian and Carboniferous, and began to assume their characteristic elegance of outline in the Triassic, in the Cretaceous attain a degree of variety and beauty that could with difficulty be excelled. It is interesting to observe that after these mollusks

had slowly attained this surpassing degree of elegance and ornamentation, the whole family became extinct. The collection contains many of these chambered shells from the Cretaceous of the Upper Missouri, which still retain their nacreous walls, that after the lapse of ages are as beautifully iridescent as any living shell. Here also are the bones of some of the great reptiles of the Cretaceous, the teeth of fishes, and a great variety of shells and plants from the same rocks. Many of these specimens are of great scientific value, as they are the type-specimens upon which many of the genera and species of Cretaceous fossils were founded.

The last case at the southern end of the geological hall contains the fossils of the Tertiary period, the last period but one before the age of man. A glance at the contents of this case shows us that all the grand divisions of animals and plants which are living at the present day, are represented. The shells of this period exhibit a very modern aspect, especially when compared with the older ones we have been studying; although many of them belong to living genera, yet nearly all the species are extinct. The tertiary plants, which are shown in great abundance, prove that the flora was not very different in its general character from that clothing the Middle States at the present day. The higher vertebrates at this time appeared in such numbers and variety that this age is known as the age of mammals.

While lingering over the cases of Silurian fossils, we attempted briefly to retrace the picture of that age, with its small and barren land areas and its great oceans tenanted by the lowest forms of animals and plants. Let us contrast with the silent barren aspect of our continent in those primeval days, its appearance in Tertiary times. North America had then attained nearly its present outline, although extensive regions along the Atlantic and Gulf borders were yet beneath the ocean, and great lakes occupied the western interior. A flora of temperate or sub-tropical growth clothed the area of the United States, and the climate of Virginia reached as far northward as Greenland. The splendid collection of Tertiary plants from the region of the Upper Missouri, the Yellowstone, and other portions of the West, shows that the banks of the Tertiary lakes, which then existed at these localities but have since been filled, were fringed with a varied and beautiful vegetation. We find among these fossil plants the leaves of the maple,

oak, hickory, conifers, etc., together with others that now grow far to the southward, as the palm, magnolia, cinnamon, and fig. Many of these fossil leaves are of double value, as they are the type-specimens from which Prof. Newberry has described and figured this wonderful flora, rich both in species and individuals. When we inquire what animals lived in these luxuriant forests, a vast menagerie of strange forms passes before us. We can do no more than call a hasty muster-roll of names. Our country was then inhabited by great numbers of animals more or less related to our modern horse, tapir, wolf, panther, stag, musk, rhinoceros, camel, llama, etc. Besides these there were a large number whose modern representatives are not so well known,—as the *Oreodon*, *Menodus*, *Uintatherium*, *Hycenodon*, and many others. This is but a meager list of the great number of Tertiary animals that have been discovered, but sufficient to show that a far richer and more wonderful assemblage of animals inhabited our land at that time than can now be found living on any continent; not even the jungles of India can produce such an array of gigantic pachyderms and carnivores as then lived in this country.

Again we are obliged to add, as with all the preceding ages, that both the luxuriant forests and these thousands of strange animals have become extinct, never again to appear on the earth. Dana remarks that "all the fishes, birds, reptiles and mammals of the Tertiary are extinct species."

As we are writing sober facts and not attempting to trace an Arabian tale, we should hesitate to speak of the times that follow the Tertiary, so strange and wonderful are they, did we not have in the collection before us the unquestionable facts engraved upon tables of stone. As the climate of the Middle States in former ages extended to Greenland, so, on the other hand, there came a time, after all the fair picture of Tertiary days was blotted out, when the present climate of Greenland, with vast snow-fields and continental glaciers, reached as far southward as New York and Cincinnati;—a time when glaciers many thousands of feet in thickness moved southward over our Northern States, grinding down the country and exterminating nearly every form of life that before had found there a congenial home. This collection contains a large number of specimens of the boulders, the boulder-clay, and the polished and scratched surfaces, that the glaciers left behind them.

After the snow and ice of this great geological winter had passed away, and a climate very similar to that which we now enjoy had covered the land with its present flora and fauna, we find the first clearly acceptable evidence of the presence of man. The geological records before us are brought down to our own time by many relics of the stone-age of Europe and America, besides a collection illustrating the arts of the Egyptians and Etruscans. Here, too, is a cast of the celebrated fossil-man of Guadaloupe, the original of which is in the British Museum.

One of the most interesting truths illustrated by the geological collections at the School of Mines, is the fact of the humble beginning of both plant and animal life on our globe, and their constant increase both in variety and specialization, as we follow their progress through the geological ages. Every one who is interested in the great question of our time—evolution—should make himself familiar with a collection of fossils arranged geologically, in order that he may see with his own eyes the facts written in the great stone book of the geologist, on which the man of science bases his theories and conclusions.

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RECENT LITERATURE.

BREHM'S ANIMAL LIFE, BIRDS.[1]—Lovers of birds, even if they are not those of the United States, will be interested in this excellent work of Dr. Brehm, of which the first two volumes lie before us. The first volume begins with an account of the skeleton, and anatomy of the soft parts, while their physiology is briefly discussed, also the motions of birds, their songs and powers of speech, sense-faculties, psychology, distribution, development, their every-day life, their courtships, pairing, nesting and breeding habits, early life and migrations. Dr. Brehm's classification is as follows: The parrots head the series and form the first order; they are succeeded by the trogons, etc. (*Levirostres*), the humming birds (*Strisores*), the fourth order of *Pici*; then come the birds of prey. The second volume completes the account of the *Accipitres*; these are succeeded by the Passerine birds, the second volume ending with the *Gyratores*, or pigeons, and the dodo. It will be seen from this enumeration that the classification adopted by the author, a distinguished German ornithologist, is somewhat unlike that of Lilljeborg, a Swedish naturalist, adopted by most American authors, as the Passeres are, at the present day, placed

[1] *Brehm's Thierleben.* Allegemeine Kunde des Thierreichs. Grosse Ausgabe. Zweite Abtheilung. Die Vogel. Von Dr. A. E. BREHM. Band 1, 2. Leipzig, 1878. 8vo. New York, B. Westermann & Co. 40 cents a part.